Nutrition

• Nutrient – a substance that promotes normal growth, maintenance, and repair
• Major nutrients – carbohydrates, lipids, and proteins
• Other nutrients – vitamins and minerals (and technically speaking, water)
- Fats, Oils, and Sweets
  Use Sparingly

- Milk, Yogurt, and Cheese Group
  2–3 Servings

- Vegetable Group
  3–5 Servings

- Meat, Poultry, Fish, Dry Beans,
  Eggs, and Nuts Group
  2–3 Servings

- Fruit Group
  2–4 Servings

- Bread, Cereal, Rice, and Pasta Group
  6–11 Servings
Food Pyramid System: Guiding Principles

- Evolutionary
- Flexible
- Useful
- Overall Health
- Up-to-Date Research
- Total Diet
- Practical
- Realistic
MyPyramid was designed to help people make food choices for meeting nutrient requirements.

Foods are grouped according to nutrient content.

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### Sample Menus for a 2000 calorie food pattern

Averaged over a week, this seven day menu provides all of the recommended amounts of nutrients and food from each food group. (Italicized foods are part of the dish or food that precedes it, which is not italicized.)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Daily Average Over One Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>2000 cal</td>
</tr>
<tr>
<td>Protein</td>
<td>56 g</td>
</tr>
<tr>
<td>Protein, % kcal</td>
<td>10%</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>264 g</td>
</tr>
<tr>
<td>Carbohydrate, % kcal</td>
<td>53%</td>
</tr>
<tr>
<td>Total fat</td>
<td>64 g</td>
</tr>
<tr>
<td>Total fat, % kcal</td>
<td>30%</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>16 g</td>
</tr>
<tr>
<td>Saturated fat, % kcal</td>
<td>7%</td>
</tr>
<tr>
<td>Monounsaturated fat</td>
<td>30 g</td>
</tr>
<tr>
<td>Polyunsaturated fat</td>
<td>23 g</td>
</tr>
<tr>
<td>Linoleic Acid</td>
<td>21 g</td>
</tr>
<tr>
<td>Alpha-linolenic Acid</td>
<td>1.1 g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>207 mg</td>
</tr>
<tr>
<td>Sodium, mg*</td>
<td>1948 mg</td>
</tr>
<tr>
<td>Potassium, mg</td>
<td>31 g</td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>1138 mg</td>
</tr>
<tr>
<td>Magnesium, mg</td>
<td>432 mg</td>
</tr>
<tr>
<td>Copper, mg</td>
<td>1.9 mg</td>
</tr>
<tr>
<td>Iron, mg</td>
<td>21 mg</td>
</tr>
<tr>
<td>Phosphorus, mg</td>
<td>1860 mg</td>
</tr>
<tr>
<td>Zinc, mg</td>
<td>14 mg</td>
</tr>
<tr>
<td>Vitamin A, mcg (RAE)</td>
<td>1430 mcg</td>
</tr>
<tr>
<td>Vitamin A, mcg (AT)</td>
<td>18.8 mcg</td>
</tr>
<tr>
<td>Vitamin C, mg</td>
<td>180 mg</td>
</tr>
<tr>
<td>Vitamin B6, mg</td>
<td>2.9 mg</td>
</tr>
<tr>
<td>Vitamin B12, mcg</td>
<td>18.4 mcg</td>
</tr>
<tr>
<td>Thiamin, mg</td>
<td>1.9 mg</td>
</tr>
<tr>
<td>Riboflavin, mg</td>
<td>2.5 mg</td>
</tr>
<tr>
<td>Niacin Equivalents, mg</td>
<td>30 mg</td>
</tr>
<tr>
<td>Dietary Folate Equivalents, mcg</td>
<td>565 mcg</td>
</tr>
</tbody>
</table>

* Starred items are foods that are labelled as no-salt-added, low-sodium, or low-salt versions of the foods. They can also be prepared from scratch with little or no added salt. All other foods are regular commercial products which contain variable levels of sodium. Average sodium level of the 7 day menu assumes no-salt-added in cooking or at the table.
Food Pyramid System Message: Physical Activity

In the Dietary Guidelines:
• Engage in regular physical activity and reduce sedentary activities to promote health, psychological well-being, and a healthy body weight

In MyPyramid graphic:
• Steps and person on them symbolize physical activity should be a part of everyday healthy living
Food Pyramid System Message: Proportionality

In the Dietary Guidelines:
• Adopt a balanced eating pattern
  – Sufficient amount of fruits and vegetables
  – 3 or more ounce equivalents of whole-grain products per day
  – 3 cup equivalents per day of fat-free or low-fat milk or milk products

In MyPyramid graphic:
• Differing widths of the color bands suggest about how much food should be eaten from each group
Food Pyramid System
Message: Moderation

**In the Dietary Guidelines:**
- Limit intake of saturated and *trans* fats, and choose products low in these fats
- Make choices of meat, poultry, dry beans, and milk products that are lean, low fat, or fat free
- Choose and prepare foods and beverages with little added sugars or calorie sweeteners

**In MyPyramid graphic:**
- Food group bands narrow from bottom to top suggesting to eat nutrient-dense forms of foods
1. Start with exercise
2. Focus on food, not grams
3. Go with plants
   - Eat a plant-based diet
4. Cut way back on American staples, e.g., red meat and refined sugars and grains
5. Take a multivitamin and maybe have a drink
Carbohydrates

• Complex carbohydrates (starches) are found in bread, cereal, flour, pasta, nuts, and potatoes
• Simple carbohydrates (sugars) are found in soft drinks, candy, fruit, and ice cream
• Glucose is the molecule ultimately used by body cells to make ATP
• Neurons and RBCs rely almost entirely upon glucose to supply their energy needs
• Excess glucose is converted to glycogen or fat and stored
Carbohydrates

• The minimum amount of carbohydrates needed to maintain adequate blood glucose levels is 100 grams per day
• Starchy foods and milk have nutrients such as vitamins and minerals in addition to complex carbohydrates
• Refined carbohydrate foods (candy and soft drinks) provide energy sources only and are referred to as “empty calories”
Lipids

- Fatty deposits in adipose tissue provide:
  - A protective cushion around body organs
  - An insulating layer beneath the skin
  - An easy-to-store concentrated source of energy
The most abundant dietary lipids, triglycerides, are found in both animal and plant foods.

Essential fatty acids – found in most vegetables, must be ingested.

Dietary fats:

- Help the body to absorb vitamins
- Are a component of myelin sheaths and all cell membranes
Lipids: Dietary Requirements

• Higher for infants and children than for adults
• The American Heart Association suggests that:
  – Fats should represent less than 30% of one’s total caloric intake
  – Saturated fats should be limited to 10% or less of one’s total fat intake
  – Daily cholesterol intake should not exceed 200 mg
Proteins

• Complete proteins that meet all the body’s amino acid needs are found in eggs, milk, milk products, meat, and fish

• Incomplete proteins are found in legumes, nuts, seeds, grains, and vegetables

• Proteins supply:
  – Essential amino acids, the building blocks for nonessential amino acids

• Daily intake should be approximately 0.8g/kg of body weight
Proteins

- Proteins supply:
  - Essential amino acids, the building blocks for nonessential amino acids
- Daily intake should be approximately 0.8g/kg of body weight
Vitamins

- Organic compounds needed for growth and good health
- They are crucial in helping the body use nutrients and often function as coenzymes
- Only vitamins D, K, and B are synthesized in the body; all others must be ingested
- Water-soluble vitamins (B-complex and C) are absorbed in the gastrointestinal tract
- Fat-soluble vitamins (A, D, E, and K) bind to ingested lipids and are absorbed with their digestion products
- Vitamins A, C, and E also act in an antioxidant
Minerals

- Seven minerals are required in moderate amounts
  - Calcium, phosphorus, potassium, sulfur, sodium, chloride, and magnesium
- Dozens are required in trace amounts
- Minerals work with nutrients to ensure proper body functioning
- Calcium, phosphorus, and magnesium salts harden bone
Metabolism

- Metabolism – all chemical reactions necessary to maintain life
- Cellular respiration – food fuels are broken down within cells and some of the energy is captured to produce ATP
  - Anabolic reactions – synthesis of larger molecules from smaller ones
  - Catabolic reactions – hydrolysis of complex structures into simpler ones
Stages of Metabolism

- Energy-containing nutrients are processed in three major stages
  - Digestion – breakdown of food; nutrients are transported to tissues
  - Anabolism and formation of catabolic intermediates
  - Oxidative breakdown – nutrients are catabolized to carbon dioxide, water, and ATP
Gluconeogenesis

- The process of forming sugar from noncarbohydrate molecules
- Takes place mainly in the liver
- Protects the body, especially the brain, from the damaging effects of hypoglycemia by ensuring ATP synthesis can continue
Lipid Metabolism

- Most products of fat metabolism are transported in lymph
- Lipids are hydrolyzed by plasma enzymes and absorbed by cells
- Only neutral fats are routinely oxidized for energy
- Catabolism of fats involves two separate pathways
  - Glycerol pathway
  - Fatty acids pathway
Protein Metabolism

- Excess dietary protein results in amino acids being:
  - Oxidized for energy
  - Converted into fat for storage
Synthesis of Proteins

- Amino acids are the most important anabolic nutrients, and they form:
  - All protein structures
  - The bulk of the body’s functional molecules
Synthesis of Proteins

- Amounts and types of proteins:
  - Are hormonally controlled
  - Reflect each life cycle stage
- A complete set of amino acids is necessary for protein synthesis
  - All essential amino acids must be provided in the diet
## Table 24.4

**Table: Thumbnail Summary of Metabolic Reactions**

<table>
<thead>
<tr>
<th>Carbohydrates</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cellular respiration</strong></td>
<td>Reactions that together complete the oxidation of glucose, yielding CO₂, H₂O, and ATP</td>
</tr>
<tr>
<td><strong>Glycolysis</strong></td>
<td>Conversion of glucose to pyruvic acid</td>
</tr>
<tr>
<td><strong>Glycogenesis</strong></td>
<td>Polymerization of glucose to form glycogen</td>
</tr>
<tr>
<td><strong>Glycogenolysis</strong></td>
<td>Hydrolysis of glycogen to glucose monomers</td>
</tr>
<tr>
<td><strong>Gluconeogenesis</strong></td>
<td>Formation of glucose from noncarbohydrate precursors</td>
</tr>
<tr>
<td><strong>Krebs cycle</strong></td>
<td>Complete breakdown of pyruvic acid to CO₂, yielding small amounts of ATP and reduced coenzymes</td>
</tr>
<tr>
<td><strong>Electron transport chain</strong></td>
<td>Energy-yielding reactions that split H removed during oxidations to H⁺ and e⁻ and create a proton gradient used to bond ADP to Pᵢ, forming ATP</td>
</tr>
<tr>
<td>Lipids</td>
<td>Proteins</td>
</tr>
<tr>
<td>----------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Beta oxidation</td>
<td>Transfer of an amine group from an amino acid to α-ketoglutaric acid,</td>
</tr>
<tr>
<td></td>
<td>thereby transforming α-ketoglutaric acid to glutamic acid</td>
</tr>
<tr>
<td>Lipolysis</td>
<td>Removal of an amine group from glutamic acid as ammonia and regenerating</td>
</tr>
<tr>
<td></td>
<td>α-ketoglutaric acid (NH₃ is converted to urea by the liver)</td>
</tr>
<tr>
<td>Lipogenesis</td>
<td></td>
</tr>
</tbody>
</table>
State of the Body

- The body exists in a dynamic catabolic-anabolic state
- Organic molecules (except DNA) are continuously broken down and rebuilt
- The body’s total supply of nutrients constitutes its nutrient pool
Absorptive and Postabsorptive States

• Metabolic controls equalize blood concentrations of nutrients between two states

• Absorptive
  – The time during and shortly after nutrient intake

• Postabsorptive
  – The time when the GI tract is empty
  – Energy sources are supplied by the breakdown of body reserves
Insulin Effects on Metabolism

• Insulin controls the absorptive state and its secretion is stimulated by:
  – Increased blood glucose
  – Elevated amino acid levels in the blood
  – Gastrin, CCK, and secretin

• Insulin enhances:
  – Active transport of amino acids into tissue cells
  – Facilitated diffusion of glucose into tissue
Diabetes Mellitus

- A consequence of inadequate insulin production or abnormal insulin receptors
- Glucose becomes unavailable to most body cells
- Metabolic acidosis, protein wasting, and weight loss result as fats and tissue proteins are used for energy
Cholesterol

- Is the structural basis of bile salts, steroid hormones, and vitamin D
- Is transported to and from tissues via lipoproteins
- Lipoproteins are classified as:
  - HDLs – high-density lipoproteins have more protein content
  - LDLs – low-density lipoproteins have a considerable cholesterol component
  - VLDLs – very low density lipoproteins are mostly triglycerides
Because triglycerides and cholesterol are insoluble in water, they do not circulate freely in the blood. Instead, they are transported to and from tissue cells bound to small lipid-protein complexes called lipoproteins. High levels of HDL are thought to protect against heart attack, while high levels of LDL increase the risk of heart attack.
• Scavenge cholesterol from the bloodstream, from the arterial walls and transports it back to the liver for breakdown

• Think of HDL as the garbage trucks of the circulatory system
Liver Metabolism

- A brief summary of liver functions
  - Packages fatty acids to be stored and transported
  - Synthesizes plasma proteins
  - Forms nonessential amino acids
  - Converts ammonia to urea
  - Stores glucose as glycogen, and regulates blood glucose homeostasis
  - Stores vitamins, conserves iron, degrades hormones, and detoxifies substances
  - Hepatocytes carry out over 500 intricate metabolic functions
Plasma Cholesterol Levels

• The liver produces cholesterol:
  – At a basal level of cholesterol regardless of dietary intake
  – Via a negative feedback loop involving serum cholesterol levels
  – In response to saturated fatty acids
Non-Dietary Factors Affecting Cholesterol

- Stress, cigarette smoking, and coffee drinking increase LDL levels
- Aerobic exercise increases HDL levels
- Body shape is correlated with cholesterol levels
  - Fat carried on the upper body is correlated with high cholesterol levels
  - Fat carried on the hips and thighs is correlated with lower levels
Body Energy Balance

• Bond energy released from catabolized food must equal the total energy output

• Energy intake – equal to the energy liberated during the oxidation of food

• Energy output includes the energy:
  – Immediately lost as heat (about 60% of the total)
  – Used to do work (driven by ATP)
  – Stored in the form of fat and glycogen
Body Energy Balance

• Nearly all energy derived from food is eventually converted to heat

• Cells cannot use this energy to do work, but the heat:
  – Warms the tissues and blood
  – Helps maintain the homeostatic body temperature
  – Allows metabolic reactions to occur efficiently
Feeding Behaviors

- Feeding behavior and hunger depend on one or more of five factors
  - Neural signals from the digestive tract
  - Bloodborne signals related to the body energy stores
  - Hormones, body temperature, and psychological factors
- When energy intake and energy outflow are balanced, body weight remains stable
- The hypothalamus releases peptides that influence feeding behavior
Hormones, Temperature, Psychological Factors

- Glucagon and epinephrine stimulate hunger
- Insulin and cholecystokinin depress hunger
- Increased body temperature may inhibit eating behavior
- Psychological factors that have little to do with caloric balance can also influence eating behaviors
Metabolic Rate

• Rate of energy output (expressed per hour) equal to the total heat produced by:
  – All the chemical reactions in the body
  – The mechanical work of the body

• Measured directly with a calorimeter or indirectly with a respirometer
Metabolic Rate

• Basal metabolic rate (BMR)
  – Reflects the energy the body needs to perform its most essential activities

• Total metabolic rate (TMR)
  – Total rate of kilocalorie consumption to fuel all ongoing activities
Regulation of Body Temperature

• Body temperature – balance between heat production and heat loss
• At rest, the liver, heart, brain, and endocrine organs account for most heat production
• During vigorous exercise, heat production from skeletal muscles can increase 30–40 times
• Normal body temperature is 36.2°C (98.2°F); optimal enzyme activity occurs at this temperature
• Temperature spikes above this range denature proteins and depress neurons
Heat production

- Basal metabolism
- Muscular activity (shivering)
- Thyroxine and epinephrine (stimulating effects on metabolic rate)
- Temperature effect on cells

Heat loss

- Radiation
- Conduction/convection
- Evaporation
Core and Shell Temperature

- Organs in the core (within the skull, thoracic, and abdominal cavities) have the highest temperature
- The shell, essentially the skin, has the lowest temperature
- Blood serves as the major agent of heat transfer between the core and shell
- Core temperature remains relatively constant, while shell temperature fluctuates substantially (20°C–40°C)
The body uses four mechanisms of heat exchange:

- **Radiation** – loss of heat in the form of infrared rays
- **Conduction** – transfer of heat by direct contact
- **Convection** – transfer of heat to the surrounding air
- **Evaporation** – heat loss due to the evaporation of water from the lungs, mouth mucosa, and skin (insensible heat loss)

Evaporative heat loss becomes sensible when body temperature rises and sweating produces increased water for vaporization.
Role of the Hypothalamus

• The main thermoregulation center is the hypothalamus

• The heat-loss and heat-promoting centers comprise the thermoregulatory centers

• The hypothalamus:
  – Receives input from thermoreceptors in the skin and core
  – Responds by initiating appropriate heat-loss and heat-promoting activities
Factors that Influence BMR

- Surface area, age, gender, stress, and hormones
- As the ratio of surface area to volume increases, BMR increases
- Males have a disproportionately high BMR
- Stress increases BMR
Heat-Promoting Mechanisms

- Low external temperature or low temperature of circulating blood activates heat-promoting centers of the hypothalamus to cause:
  - Vasoconstriction of cutaneous blood vessels
  - Increased metabolic rate
  - Shivering
Heat-Loss Mechanisms

• When the core temperature rises, the heat-loss center is activated to cause:
  – Vasodilation of cutaneous blood vessels
  – Enhanced sweating

• Voluntary measures commonly taken to reduce body heat include:
  – Reducing activity and seeking a cooler environment
  – Wearing light-colored and loose-fitting clothing
Hyperthermia

• Normal heat loss processes become ineffective and elevated body temperatures depress the hypothalamus
• This sets up a positive-feedback mechanism, sharply increasing body temperature and metabolic rate
• This condition, called heat stroke, can be fatal if not corrected
Heat Exhaustion

- Heat-associated collapse after vigorous exercise, evidenced by elevated body temperature, mental confusion, and fainting
- Due to dehydration and low blood pressure
- Heat-loss mechanisms are fully functional
- Can progress to heat stroke if the body is not cooled and rehydrated
Fever

- Controlled hyperthermia, often a result of infection, cancer, allergic reactions, or central nervous system injuries
- White blood cells, injured tissue cells, and macrophages release pyrogens that act on the hypothalamus, causing the release of prostaglandins
- Prostaglandins reset the hypothalamic thermostat
- The higher set point is maintained until the natural body defenses reverse the disease process
Developmental Aspects

- Good nutrition is essential *in utero* as well as throughout life
- Lack of proteins needed for fetal growth and in the first three years of life can lead to mental deficits and learning disorders
- With the exception of insulin-dependent diabetes mellitus, children free of genetic disorders rarely exhibit metabolic problems
- In later years, non-insulin-dependent diabetes mellitus becomes a major problem